APPENDIX G

SURFACE GEOPHYSICAL STUDY REPORT

During the summer of 1986, Kennecott contracted the firms of Mackelprang & Associates and Practical Geophysics to conduct and interpret surface geophysical resistivity transects at seven sites in the study area (Figure G-1). The results of the survey are summarized in the cross sections G-2 through G-8. Specifications on the field equipment used are also presented at the end of this section.

The purpose for conducting this survey was to define permeable subsurface channels that might serve as conduits for groundwater contaminant movement from potential contaminant source areas.

Although surface geophysical resistivity data is typically highly interpretive and not exact, the geologic and water quality data from new and existing wells located along and near the seven transects contributed significantly in completing the data interpretation. A summary of the evaluations for each line is presented below:

Line 1

Line 1 was run in a north-south direction east of Kennecott's new evaporation ponds over a 4000 foot length, with a 7-spread dipole-dipole array 250 foot dipole spacing. Under optimal conditions, the data would reflect the electrical response in the upper 750 feet. Dry clayey materials were encountered in the upper zone, with possibly higher permeability sands and/or gravels near stations 2-3 south and 3-5 north (Figure G-2).

Line 2

Line 2 was run along a 4000 foot east-west line just south of Kennecott's new evaporation ponds and on the southside of 11800 South (Figure G-1). Center station 0 is near the southwest corner of the lined evaporation pond with station 8 east approximately 300 feet west of the irrigation canal and Line 1. Dipole spacing on line 2 was also 250 feet. Since there are power and water lines in this area, there may have been some interference.

As illustrated in Figure G-3, the apparent resistivity increased from west to east, with possibly a gravelly layer near the western end and clays towards the eastern end.

Line 3

Line 3 was run along a 4000 foot line in a north-northwest to south-southeast direction just east of the old town of Lark (Figure G-1). The line center (station 0) is on a dirt road running south of the old Lark tailings.

Figure G-4 illustrates the results of the survey. Drainages between stations 0-5 and 6-8 show slightly more conductivity, probably from high TDS waters flowing in the gulley at station 2N and in Mascotte Ditch. Higher apparent resistivities between stations 0-2 south and 5-7 south extend across topographically low areas and may reflect volcanics underlying the alluvium.

The lower resistivity value between stations 3 and 4 south, at Copper Creek, were not caused from surface waters, but possibly from shallow groundwaters in the creek gravels.

The IP data are typical of alluvial fan material containing mostly sand and gravels with minimum clay content. The shallow IP data greater than 10 Msec may result from pyrite in the old dump and the deep higher IP values may reflect volcanics below the alluvium.

Line 4

Line 4 was run in a north-south direction just west of the old town of Lark (Figure G-1). Stations were spaced at only 50 foot intervals in order to evaluate shallow conditions, at 15 spread electrode sites, with a total line length of 1350 feet. The resistivity data are highly variable. However, the lithologic logs from wells P244A and C indicate clayey sediments to about 40 feet that may give rise to the shallow values of 7.5 and 10 ohm meters. Volcanics may occur near stations 0, 5 and 7 north.

Highly conductive fluids may occur beneath stations 1-3 south, 4-5 south, 0-1 north, 1-4 north and 6 north, as monitored at shallow well P244A.

Topography and power lines may have influenced the resistivity data to the north, from stations 3 to 5 north and 11 to 14 north. Station 14 north lies on the upper edge of a large wash, at least 100 feet lower in elevation. Stations 1-3 south extend across a large gulley, with 3 south in the gulley bottom. Stations 6-9 south rise out of the gulley with stations 8 and 9 along the gulley's south bank.

Line 5

Line 5 was run in a north-south direction across Midas Creek (Station 7 north) over a 2100 foot length at 50-foot intervals (Figure G-1). This line was designed to test for conductive fluids within the gravels of upper Midas Creek.

Low resistivities from Stations 3 north to 11 north (i.e. less than 5 ohm meters) indicate the presence of contaminated fluids along the Midas Creek drainage. However, the low resistivities from station intervals 10-15 north may result from topographic effects.

The low conductivity observed at station 23 north may be caused by a large power line.

The higher resistivities, (1) at stations 5 north - 2 south may be due to gravels; (2) at station 4 may be due to topography; (3) at stations south of 5 south due to shallower volcanics.

Lower resistivities between stations 9 to 20 north may result from the topographic slope in this area, near surface clayey sediments or possibly from shallow groundwaters. Low resistivities near station 4 south and stations 0-2 north may be due to the presence of clays, old buried pipelines paralleling the road or lithologic changes from faulting.

Line 6

Line 6 trends north-south with 250 foot dipoles, a length of 4500 feet and well P241B, located midway between stations 0 and 1 south, and in a topographic depression.

The purpose for running this line was to evaluate if there were any subsurface permeable channels that may have contributed to groundwater contaminant flow as currently observed in wells P241B and P202C.

A surface ditch with iron staining has been located that runs from Bingham Creek channel near the reservoir to this general area. It is believed that this natural depression was once used to store leach fluid.

The shallow low resistivity zone beneath stations 0-1 south may reflect the shallow silts and clays. The conductive diagonal from stations 0 to 1 north may be caused by a resistivity contact or possibly well casing, but it is probably, based on the water quality data, due to contaminated groundwater. Although the water table is deep (335 feet), the fluid conductance is around 18,000 umhos/cm or expected surface resistivities of about 5.6 ohm meters. The observed values of 30 ohm meters or less are not unexpected and could easily be associated with contaminated groundwater.

More resistive material between stations 10-13 south indicate a buried channel. High resistivity values between 50-216 ohm meters south of the depression indicate an increase in gravel content near surface (i.e. stations 3-12 south).

The lower resistivities to the south may be due to a thicker deposition of well sorted clays and silts caused by sediment reworking during Lake Bonneville time. The southern end of Line 6 is on the flank of a large embankment centered on Midas Creek.

Line 7

Line 7 was run over a length of 5,250 feet, in a north-south line just east of Kennecott's 500 million gallon reservoir (Figures G-1 and G-8).

Numerous cultural features were encountered which interfere with the data (i.e. metal fences, power lines, railroad tracks). However, resistivity values of less than 10 ohm meters are definitely associated with the poor quality shallow acidic waters that have seeped from the reservoir (i.e. from Sections 5 north to 4 south).

Deeper but much less contaminated waters that may have seeped from the reservoir are present from Sections 7 north to 5 south. Stations 4 to 8 south are out of the Bingham Creek drainage and extend south onto cultivated wheat fields. The water quality in well K105 to the south, however, does not indicate contamination by reservoir seepage, with TDS levels of around 400 mg/l.

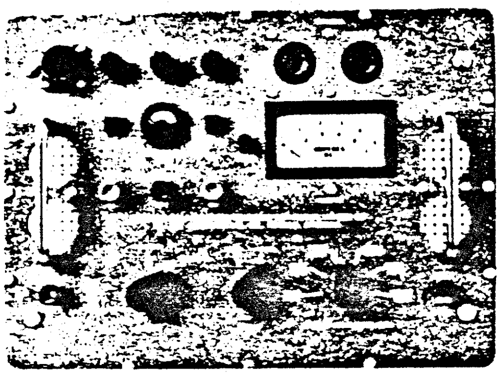
In 1968, surface resistivity lines were run along Bingham Creek, downgradient from the reservoir (Figure G-9). The results are similar to the 1986 data, in that low resistivity values corresponding to contaminated groundwaters, were observed along the creek channel.

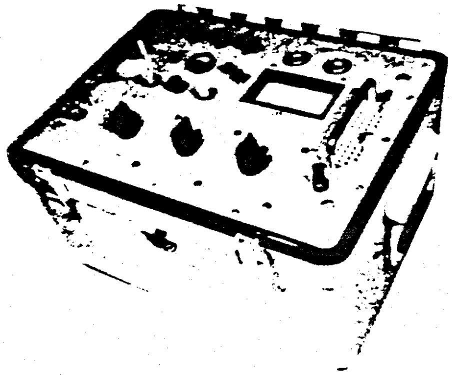
In 1964, a seismic refraction study was conducted by Kennecott's Bear Creek Mining Company's Geophysical Division in the area east of the leach dumps, from approximately 10,800 north to 17,000 north and 20,000 east to 30,000 east (Figure G-10). The study results indicate that four (4) east-west trending channels could be present in the alluvium and terminate at the alluvial (volcanic) bedrock interface.

Seismic channel 1-a corresponds with the present Bingham Creek channel and indicates depth to volcanics at around 120 feet. Channels 1-b and 2 may also reflect old creek channels.

Channels 2 and 3 may have served as pathways for historic leach water movement to the east. Monitor wells P202C and P241B and A, and P208A may be monitoring such shallow groundwater contaminant movement along Channel 2. Monitor well P274 to the south, however, intercepts Channel 3 and intercepts very good quality groundwaters (pH-8.11, conductivity = 950 umhos/cm^3).

TIME DOMAIN I P TRANSMITTER
MODEL 15A





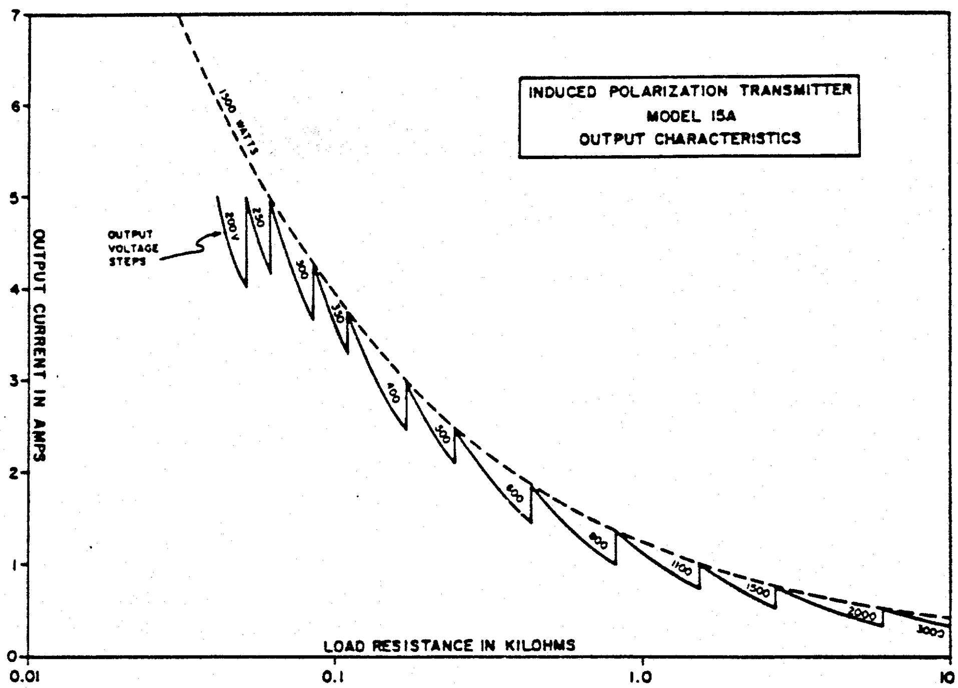
FEATURES

- ✓ All solid state circuitry and power switching for dependability.
- ✓ Plug in PC board circuitry for rapid field maintenance.
- ✓ Failsafe monitor circuitry for input over voltage, output over power, and power switching failures.
- ✓ Transient protected high voltage rectifiers.
- ✓ Symmetrical time domain output waveform.
- ✓ Output selectable to closely match current loop impedance.
- ✓ Readily customized to specific applications.
- ✓ Simplified operation requiring minimum training of personnel.
- ✓ Foolproof design.
- ✓ Heavy duty sealed aluminum case.

MELANO - PYXIS

Geophysical Equipment

179 EAST 2450 SOUTH • BOUNTIFUL, UTAH 84010 • (801) 292-4041

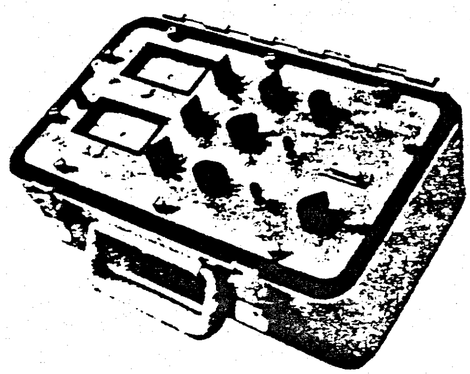


SPECIFICATIONS

INPUT POWER:	120 volt 400 Hz single phase at 1800 VA, relatively insensitive to input voltage/ frequency regulation.
OUTPUT POWER:	1500 watts.
OUTPUT VOLTAGE:	200 to 3000 volts in 12 switch selected steps.
OUTPUT CURRENT:	5 Amps maximum. (see above figure).
OUTPUT IMPEDANCE DRIVE:	40 ohms to over 10,000 ohms.
TIME CYCLE:	On/off periods (symmetrical) adjustable at factory from 0.5 to 10 seconds.
TEMPERATURE RANGE (AMBIENT):	-15°C to +60°C (+5°F to 140°F).
WEIGHT, COMPLETE WITH CASE:	45 pounds.
DIMENSIONS, IN CASE:	10.5 inches high by 16 inches wide by 11.5 inches deep.

TIME DOMAIN I P RECEIVER
MODEL R-10A

FEATURES



✓ State-of-the-Art, four channel time domain receiver for transient decay curve shape analysis, rapid signal-to-noise enhancement, and maximum rejection of EM coupling effects.

✓ Specialized circuitry for maximum rejection of telluric noise.

✓ Compatible with conventional time domain transmitters.

✓ Custom designed preselectable features for: time cycle, scaled output, integration window widths and positions, and window composite output.

✓ Primary voltage range of 150 microvolts to 100 volts.

✓ Remotely sensed automatic time lock to transmitter signal.

✓ Integration circuitry for primary SP buckout and automatic SP tracking.

✓ Four integration windows are integrated concomitantly with selectable readout of any integration window or a weighted composite output (sum or average of 1 to 4 windows).

✓ Each window readout is scaled independently for decay curve tracing or variably scaled for identical response per channel for rapid field analysis of signal-to-noise enhancement.

✓ Automatic cycle counter for 1, 2, or 5 cycles.

✓ Self-contained calibrator.

✓ Built in input electrode loop continuity meter.

✓ Buffered digital and analog signal outputs on front panel for recording.

✓ Low battery drain using low power linear IC OpAmps and digital COS/MOS.

✓ Choice of rechargeable Ni-Cd battery pack with auxiliary constant current charger or replaceable carbon battery pack in field plugin units.

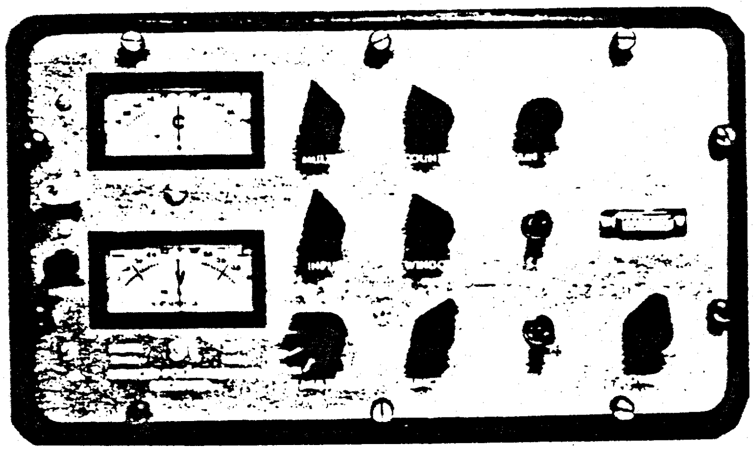
✓ All active circuitry mounted on field-replaceable PC boards.

✓ Sealed switches and coated PC boards for long term dependability.

MELANO - PYXIS

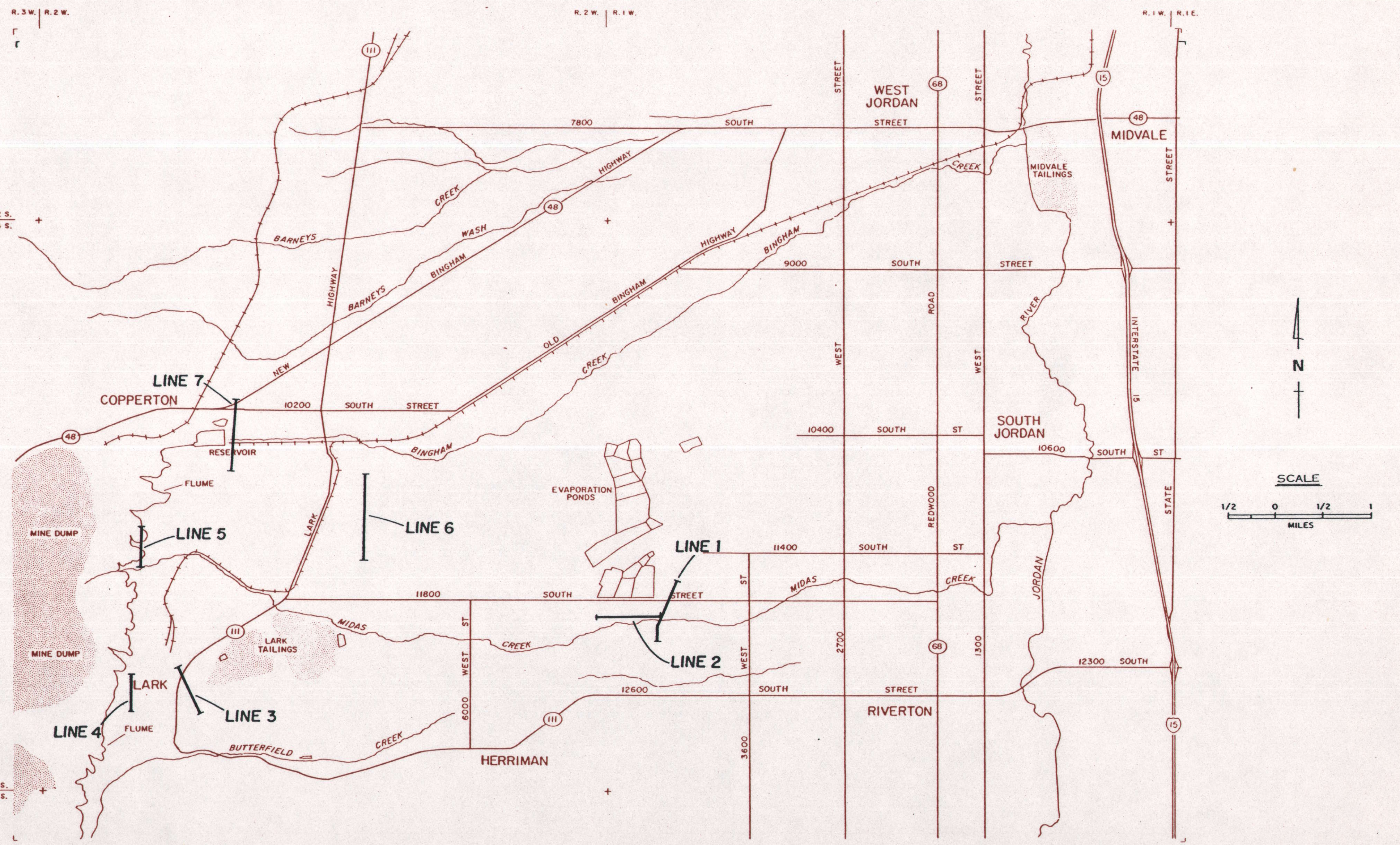
Geophysical Equipment

179 EAST 2450 SOUTH • BOUNTIFUL, UTAH 84010 • (801) 292-4041



SPECIFICATIONS

INPUT IMPEDANCE:	> 5 megohms.
POWERLINE REJECTION 60 Hz (or 50 Hz):	55 db minimum.
PRIMARY VOLTAGE (V) RANGE IN 1-2-5 STEPS:	0.15×10^{-3} to $1.0 \times 10^{+2}$ volts.
ACCURACY OF V MEASUREMENT:	± 5% of full scale.
CHARGEABILITY (C) RANGE IN 1-2-5 STEPS:	0 to 1000 arbitrary units.
ACCURACY OF C MEASUREMENT:	± 5% of full scale.
PRIMARY SP BUCKOUT RANGE:	± 2.0 volts.
AUTOMATIC SP TRACKING RANGE:	± 1000% of V limited to ± 2.0 volts.
ANALOG METER RESOLUTION:	± 2% of full scale.
CONTINUITY METER RANGE FOR 1% LOADING:	0 to 60 kilohms.
REQUIRED STABILITY OF TRANSMITTER FREQUENCY:	± 5%.
TEMPERATURE RANGE OF OPERATION (ambient):	$-30^{o}C$ to $+60^{o}C$ ($-22^{o}F$ to $+140^{o}F$).
DIMENSIONS IN CASE:	7" high by 13½" wide by 8" deep.
WEIGHT COMPLETE WITH CASE AND COVER:	13 pounds (approximate).

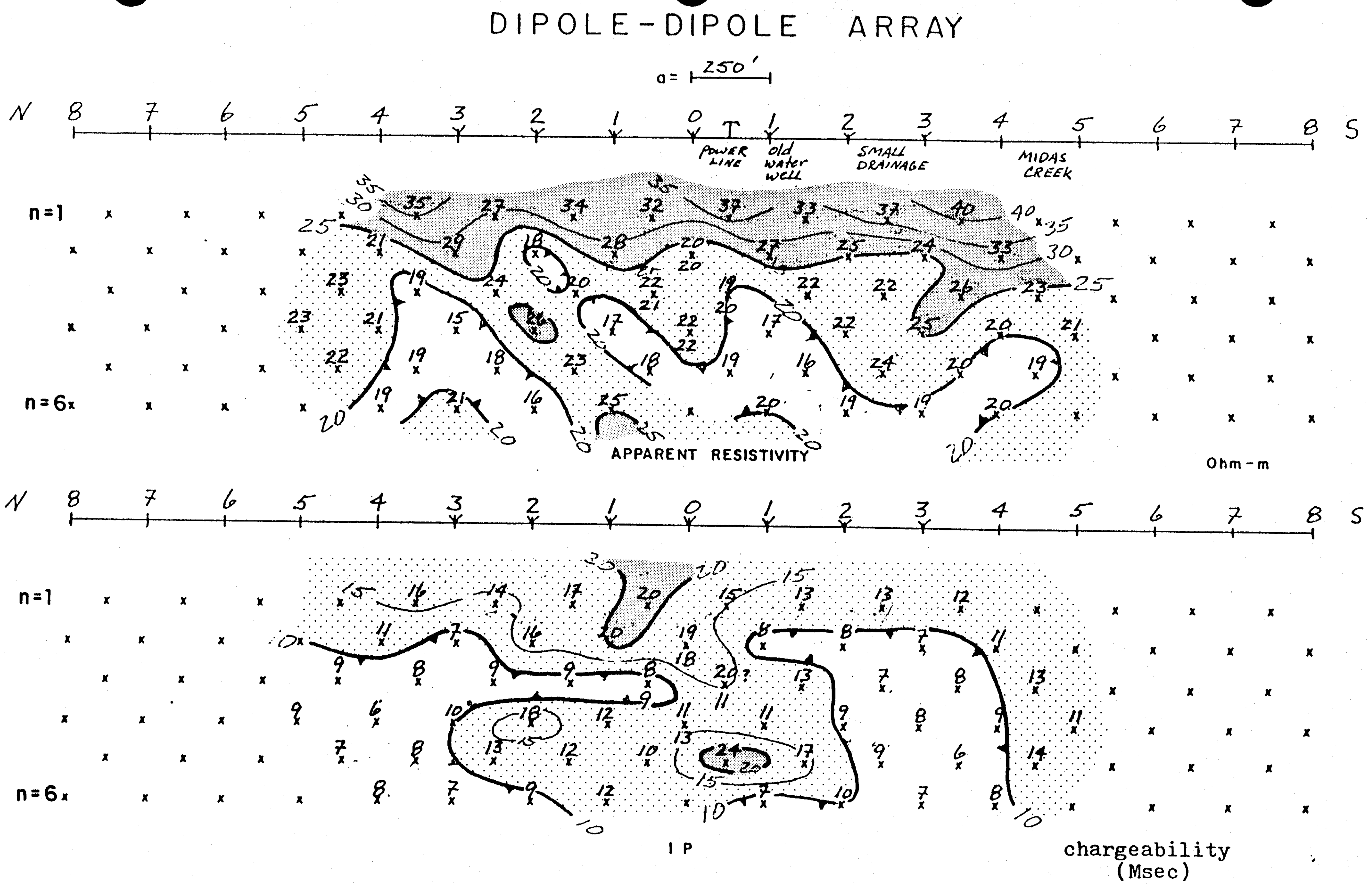


LINE BASE ADAPTED FROM U. S. G. S. QUADRANGLES ENTITLED
1) "LARK, UTAH" – 1952, PHOTOREVISED 1969 & 1975.
2) "MIDVALE, UTAH" – 1963, PHOTOREVISED 1969 & 1975.

SURFACE RESISTIVITY
GEOPHYSICAL LINES
NUMBERS 1 THRU 7

Dames & Moore

FIGURE G-1



AREA Midas Creek STATE Utah LINE 1 DATA BY CEM DATE 5/86 TRANSMITTER 15 A RECEIVER R10A

FIGURE G-2. RESISTIVITY LINE 1 – EAST OF NEW EVAPORATION PONDS

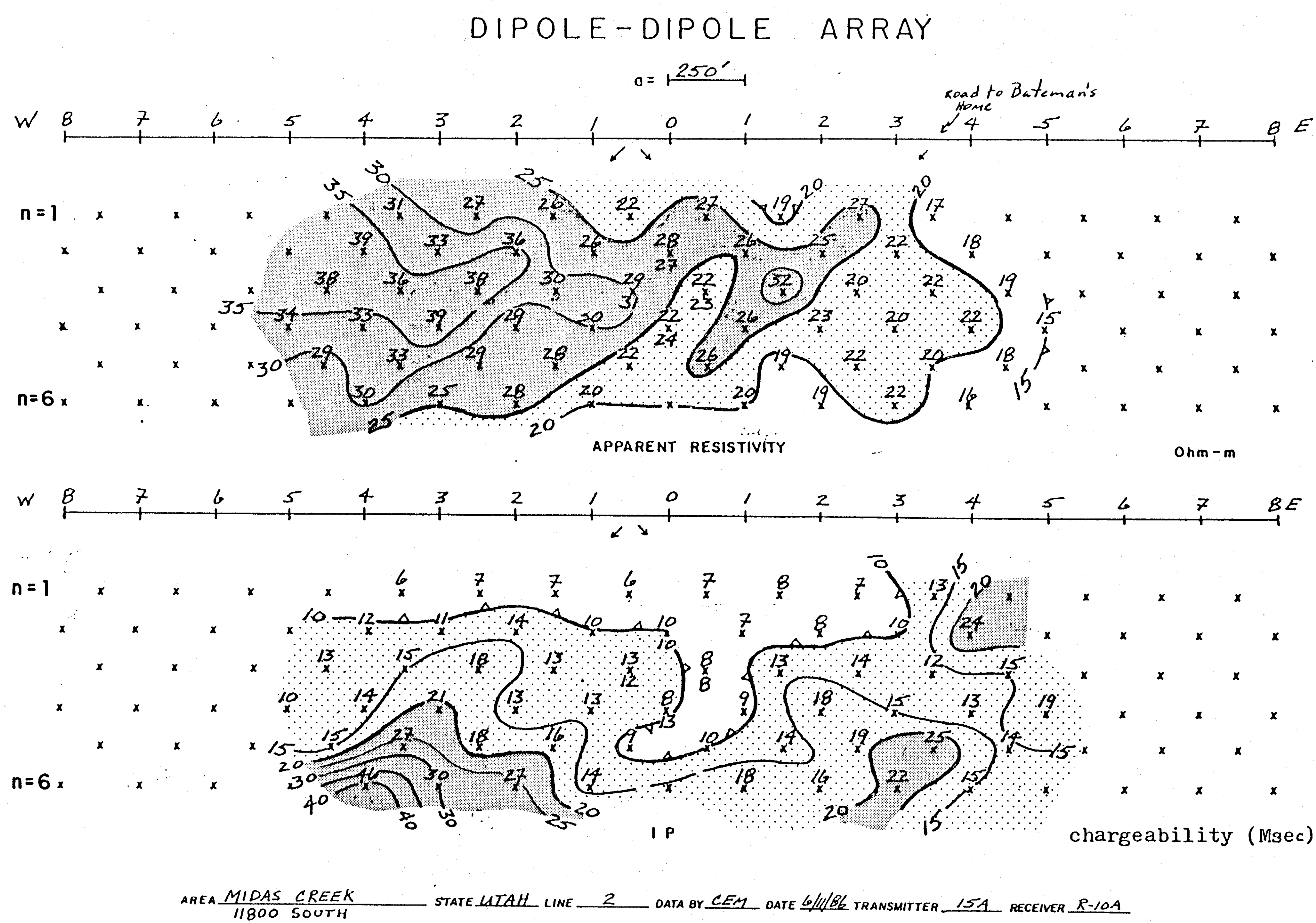
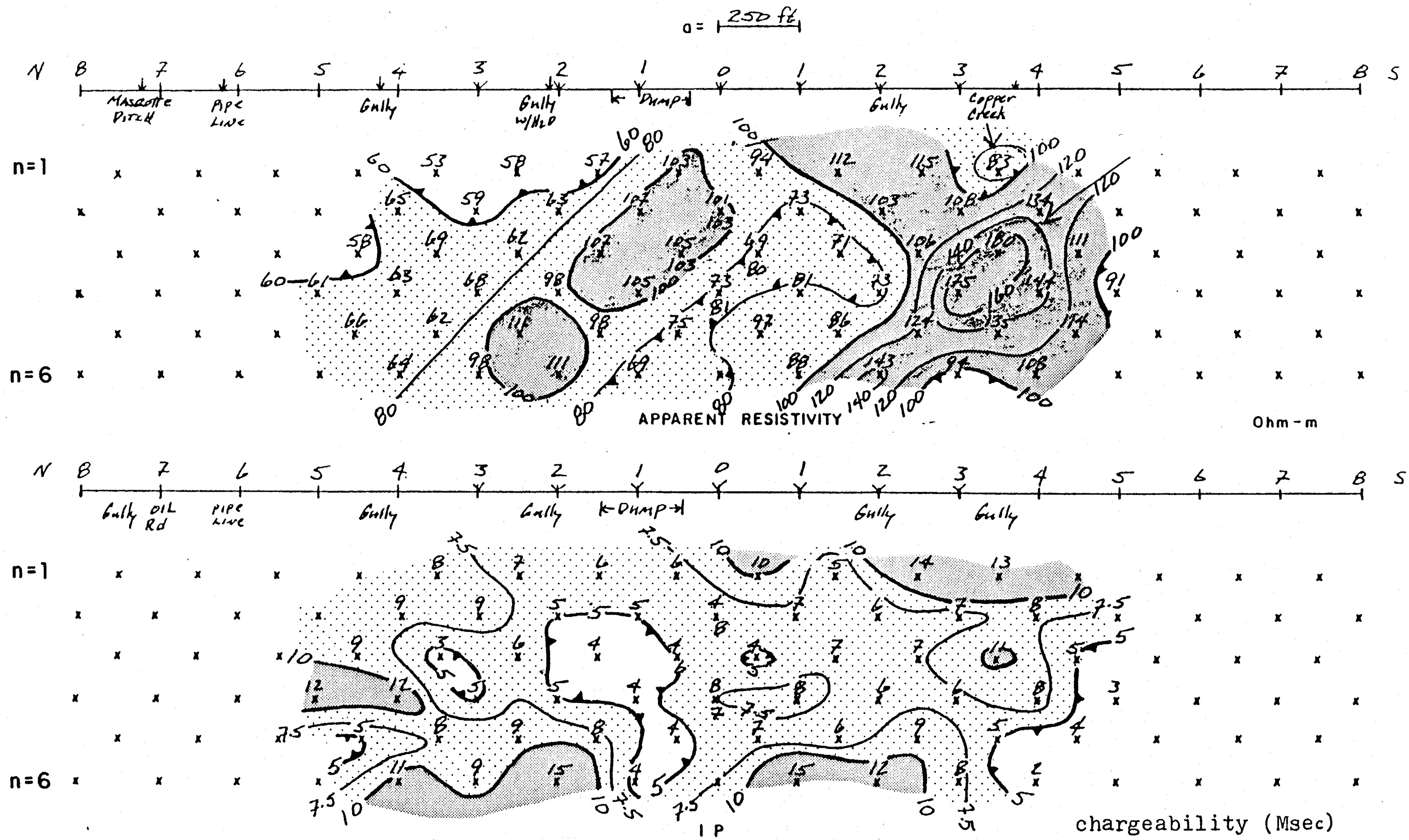


FIGURE G-3. RESISTIVITY LINE 2 – SOUTH OF NEW EVAPORATION PONDS

DIPOLE-DIPOLE ARRAY



AREA MIDAS CREEK STATE UTAH LINE 3 DATA BY CSM DATE 6/19/85 TRANSMITTER MISA RECEIVER R-10A

FIGURE G-4. RESISTIVITY LINE 3 – SOUTHWEST OF LARK TAILINGS

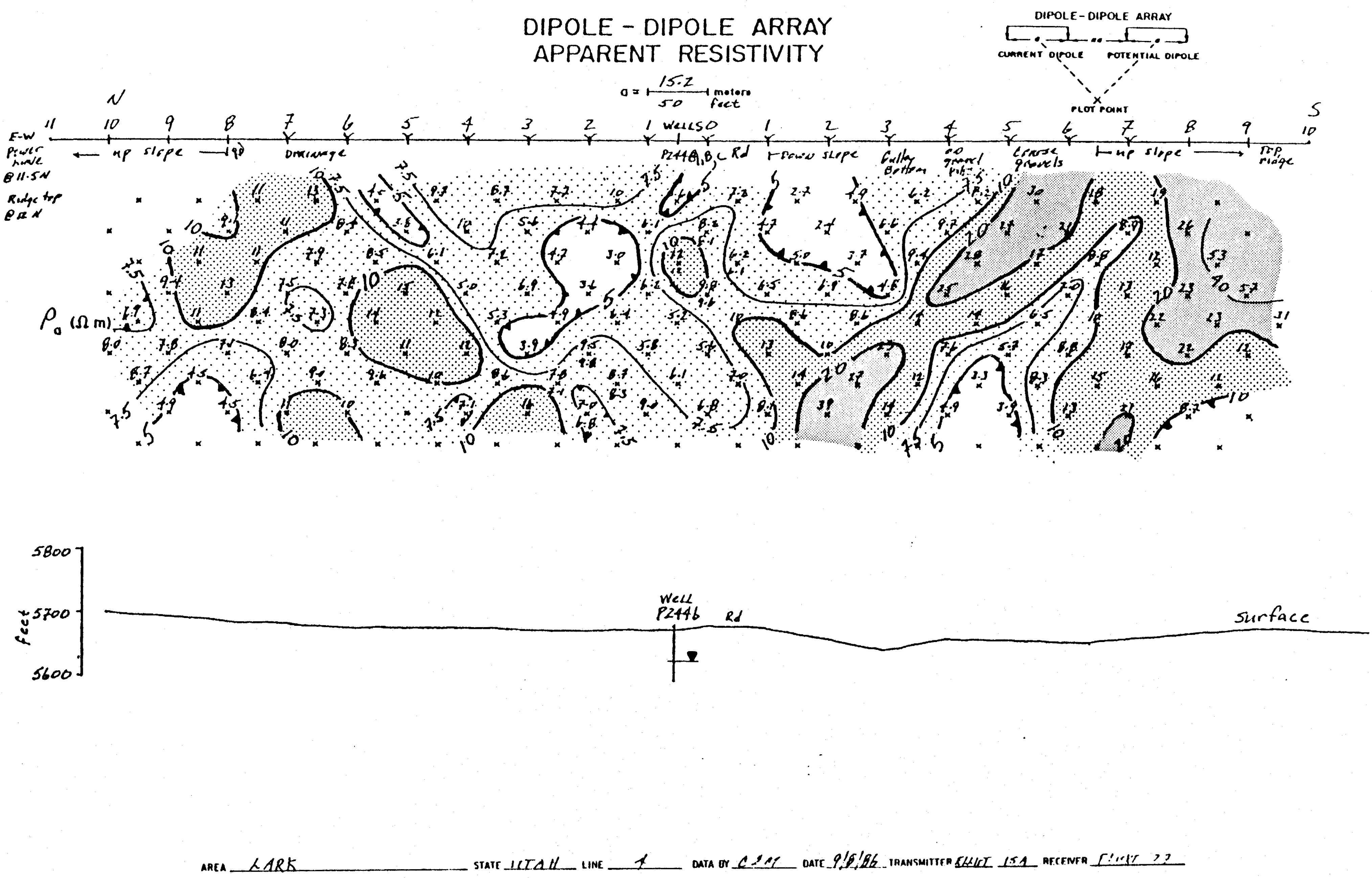


FIGURE G-5. RESISTIVITY LINE 4 - EAST OF LARK

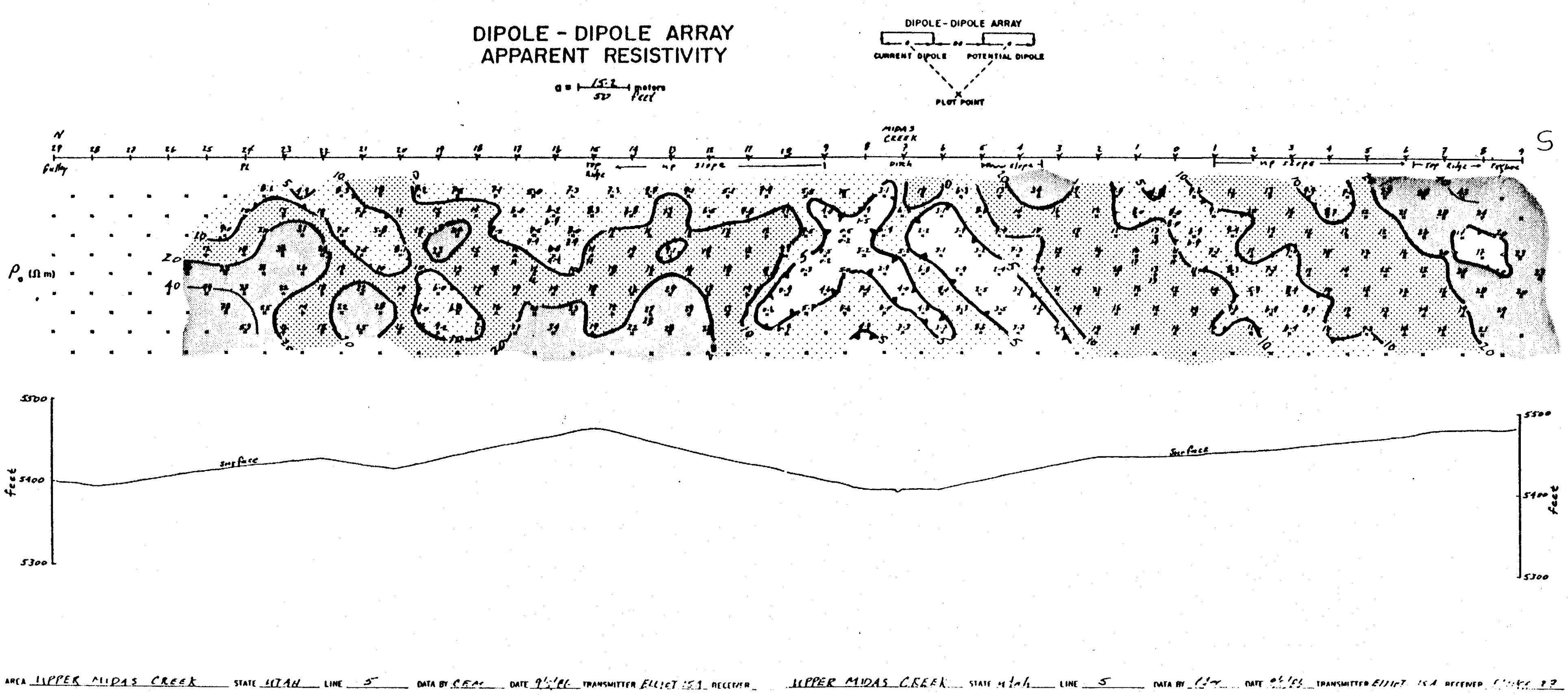
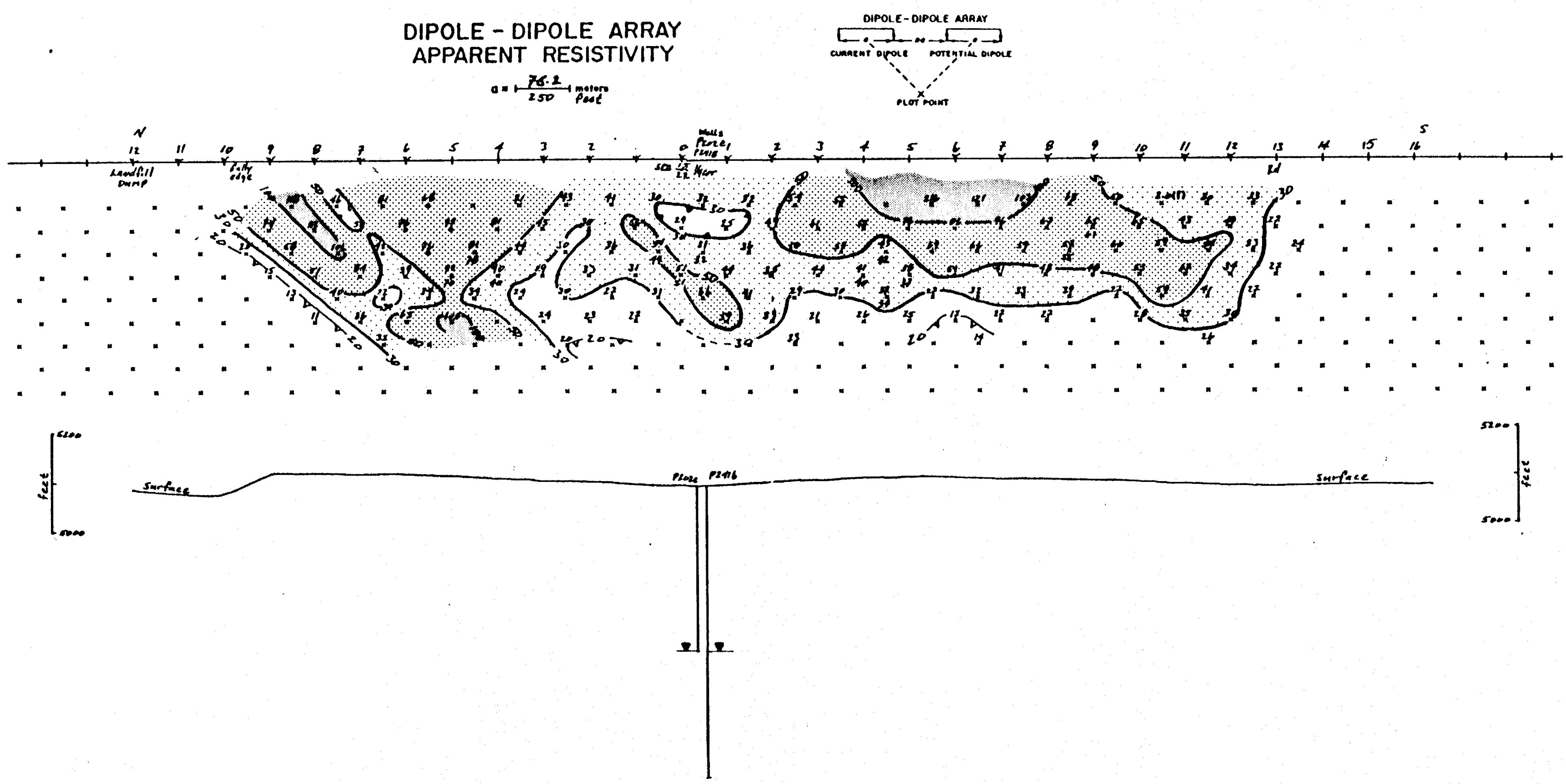
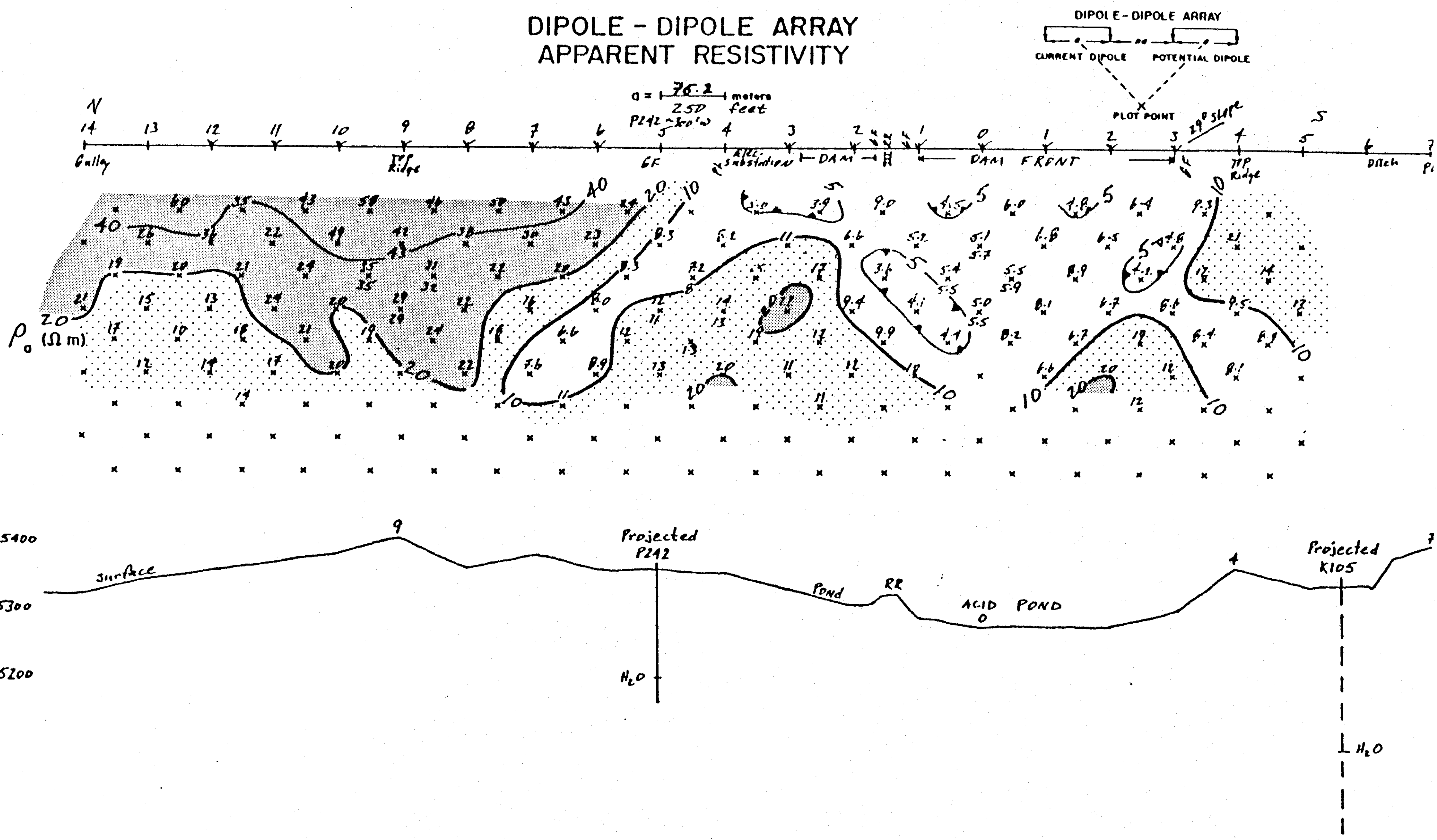


FIGURE G-6. RESISTIVITY LINE 5 – EAST ALONG MIDAS DRAINAGE



AREA DEPRESSION AREA STATE UTAH LINE 6 DATA BY ____ DATE 9/3/84 TRANSMITTER ELLIOT ISA RECEIVER FLUKE 27

FIGURE G-7. RESISTIVITY LINE 7 – ALONG DEPRESSION, P241B



AREA Bingham Acid Pond STATE Utah LINE 7 DATA BY [illegible] DATE 9/11/86 TRANSMITTER Elliot 15A RECEIVER Fluke 27

FIGURE G-8. RESISTIVITY LINE 7 - EAST OF RESERVOIR

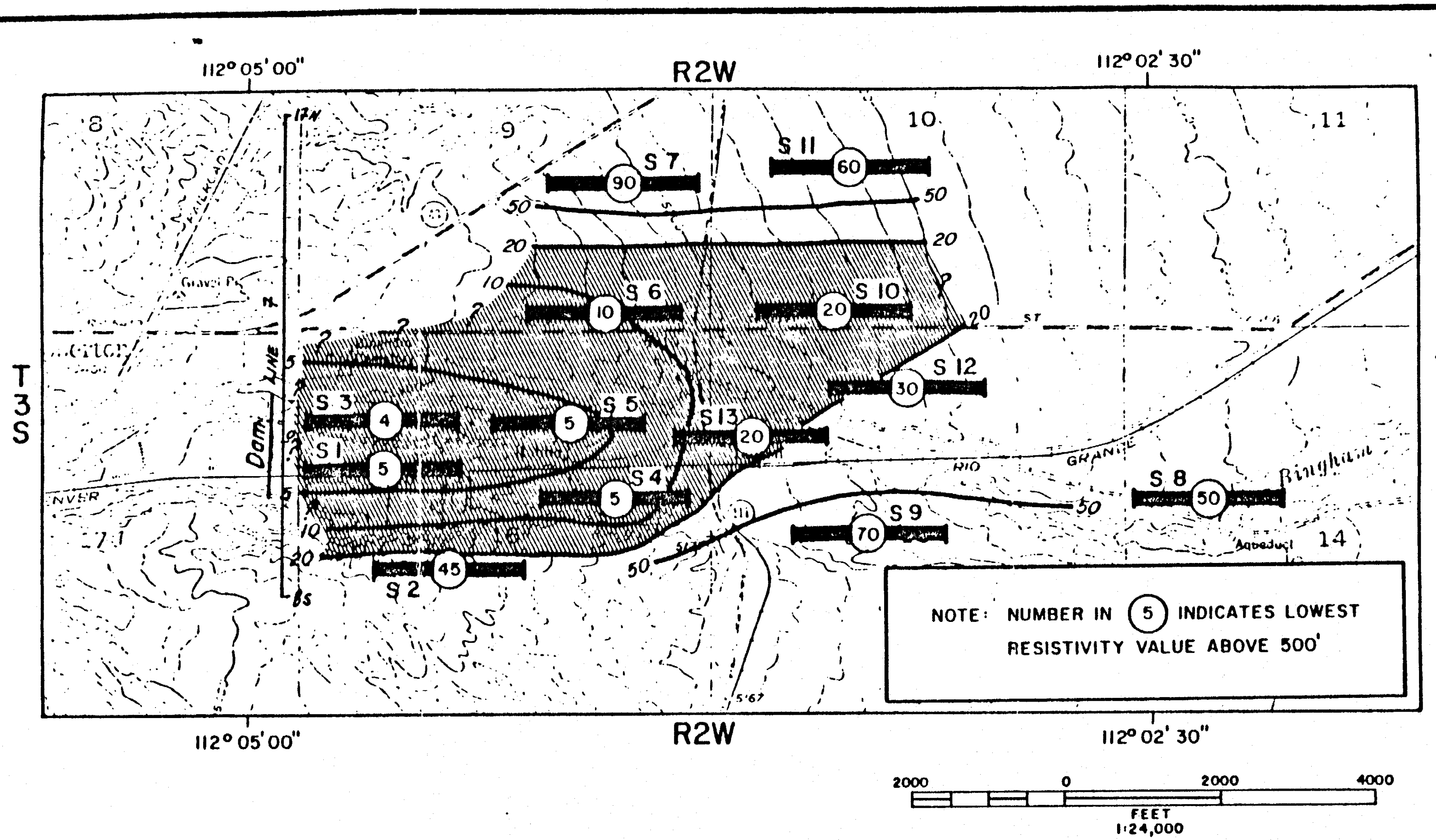
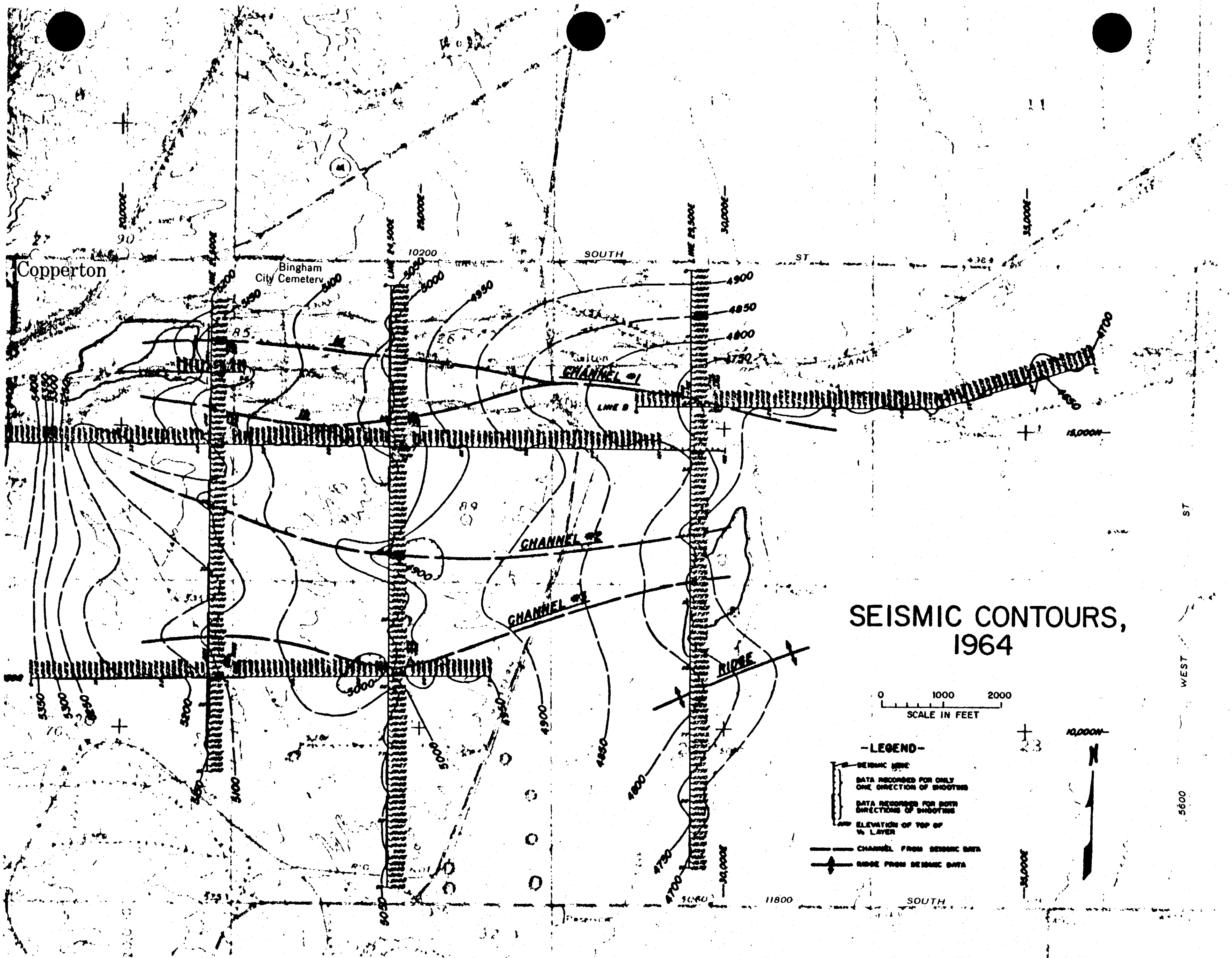


FIGURE G-9. RESISTIVITY CONTOUR MAP – EAST BINGHAM CANYON (AFTER VAN VOORHIS, 1968).



SEISMIC CONTOURS, 1964
0 1000 2000
SCALE IN FEET
-LEGEND-
SEISMIC LINE
DATA RECORDED FOR ONLY ONE DIRECTION OF SHOOTING
DATA RECORDED FOR BOTH DIRECTIONS OF SHOOTING
ELEVATION OF TOP OF V₂ LAYER
CHANNEL FROM SEISMIC DATA
RIDGE FROM SEISMIC DATA
Copperton
Bingham City Cemetery
CHANNEL #1
CHANNEL #2
CHANNEL #3
RIDGE
LINE B
SOUTH
ST
WEST
10200
11800
5600
20,000E
25,000E
30,000E
35,000E
15,000N
10,000N

FIGURE G-10